MEMORIAL UNIVERSITY OF NEWFOUNDLAND

DEPARTMENT OF MATHEMATICS AND STATISTICS

A3 **MATH 6205** DUE: FEB. 9$^{\text{TH}}$, 2022

Upload your solution to Brightspace at the beginning of class on Wednesday Feb. 9$^{\text{th}}$, 2021.

1. The *CIFAR-10* dataset consists of a total of 60,000 colour images of dimensions 32×32 with a total of 10 classes. There are 50,000 training images and 10,000 test images.

   Develop a feedforward neural network (i.e. a MLP) for image classification for this dataset. Experiment with the number of hidden layers, units per layer, activation functions, etc.

   Verify the model(s) by reporting suitable metrics, such as accuracy, precision, recall, per-class accuracy, etc. What overall accuracy can your model obtain for this dataset? Visualize some of the correct and incorrect predictions of your model.

   Note: You will find that the MLP network is woefully inadequate for this dataset. As with most image-related problems, convolutional neural networks are vastly superior, and we will learn about these in class soon.

2. Download the *St. John's temperature* dataset from Brightspace. This dataset records hourly reanalysis data of the two-meter temperature near St. John's, NL from 2011–2020 (10 years). The goal is to develop a feedforward neural network to predict the temperature for the next 6 hours.

   Complete the following tasks:

   (a) *Develop suitable baseline models.* The simplest baseline for a prediction task like this is the so-called *persistence* prediction: You simply assume that the temperature for the next 6 hours will be the same as the last observed temperature. A second baseline is a simple linear regression model.

   (b) *Training and testing data.* Use 80% of the data for training and 20% of the data for testing. Since the data represents a time series, which has a natural ordering, be careful how you split and/or shuffle the data.

   (c) *Experiment with various hyperparameter for your neural network model*, e.g. varying the number of hidden layers, units per layer, activation functions, etc.

   (d) *Visualize some of the predictions* from the two baseline models and the feedforward NN model, along with the true labels.

   (e) *Verify the models on the test dataset*, using the mean squared error as verification metric. In particular, plot the mean squared error of the models as a function of the prediction time step.

   (f) *Experiment with the number of input steps* for your model to predict the temperature for the next 6 hours, e.g. using the past 6 hours, the past 12 hours or the past 24 hours.

   (g) Can your feedforward neural network models beat the two baselines consistently?

Note: The dataset is stored in the NetCDF file format, which is popular in the atmospheric sciences. As such, you have to import this data into a `numpy` or `tf.data Dataset` first, which can be done with the `netcdf4` API. This temperature data was obtained from the Copernicus Climate Data Store, and is based on the ERA5 reanalysis data. For more information on this dataset (or if you want to download climate data yourself for your own ML projects), consult `https://climate.copernicus.eu/climate-reanalysis`.